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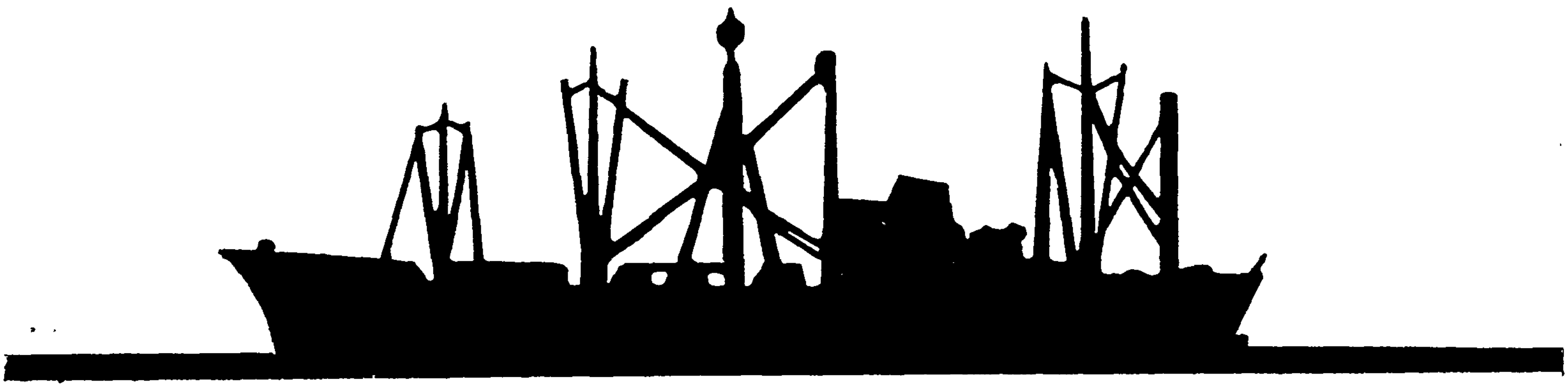

INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

I R E A P S

0009 #25

CLASSIFICATION AND CODING: A TOOL TO ORGANIZE INFORMATION

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Mr. Houtzeel has 20) years. of experience in engineering and management. He established the American office of TNO, The Netherlands, in 1970. He has been a pioneer in the introduction of Group Technology to the United States. Prior to joining TNO, Houtzeel was a Project Leader at the U.S. Atomic Energy commission's Oak Ridge, Tennessee facility. His responsibility there included analyzing the reactor component performance of the experimental molten salt reactor. From 1966-1968, he was General Manager of a Luxembourg company that designed and manufactured nuclear equipment. He worked on the design and mechanical testing of nuclear equipment in Grenoble, France for the French Atomic Energy Commission and for the U.S. Atomic Energy Commission at Oak Ridge before that.

Mr. Houtzeel earned his mechanical engineering degree at the Institute of Technology in Delft, the Netherlands and went on to study nuclear engineering at the Institut National ds Sciences et Techniques Nucleaires, Saclay, France. He also holds an MBA degree from the European Institute of Business Administration in Fontainebleau, France.

ABSTRACT

The uses of classification and coding as a tool to integrate computer-aided design and manufacturing are described. The information revolution has created an enormity of data which is increasingly difficult to access. In recent years, companies have turned to classification and coding systems as a means of organizing raw data and retrieving useful relevant information. Essentially, classification is a means of separating raw information into classes of similar information; coding is a means of retrieving the information so that it can be analyzed and applied to accomplish specific objectives. The MULTICLASS system enables the user to employ multiple coding systems that can be used for various information retrieval and analysis purposes i.e., retrieval and standardization of manufacturing information, assembly information, tool retrieval, electronics, material selection and use.

BACKGROUND

Early Coding and Classification

Coding and classification systems have been used for many years - in libraries, for example, and in other information retrieval applications. Such systems were not widely used in the manufacturing industry, however, until after World War II.

In the late 1940's and early 1950's, systems were developed for the manufacturing industry. They were primarily intended for design retrieval.

They were highly customized code systems, utilizing five to eight digits to describe design attributes of machined and other parts.

The vendor/consultant would work with the potential user to determine types of classifications to be incorporated into the system, and the number of items per class. In actual practice, the user determined the the number of parts in each class, although the vendor/consultant might provide some guidance.

The vendor/consultant would then analyze the customer's part designs, going over several thousand to as many as ten thousand parts. The designs would then be arranged in groups, and the system would be built around these groups. It was usually a manual system, based on hierarchical principals. (See Figure 1.) In other words, the value of each digit depended on the value of the digit preceeding it. For example, the number five in the second position would have one meaning if the first position number indicated a turned part, and a totally different meaning if the first position digit indicated a box form (i.e. a different branch of the hierarchical tree).

This approach worked very well in the United States and Europe (including Eastern Europe) for design retrieval purposes. The Brisch - Birn System is a good example. Such systems did not normally accommodate manufacturing requirements, however.

Application to Manufacturing

In the late 1950's and early 1960's, manufacturing oriented research was carried out in several European countries, including Germany, particularly at the University of Aachen. Researchers surveyed parts being made by the German machine tool industry.

It became evident that although the designs and functions might be different, there were many similarities in the parts being manufactured. This was not only true within individual companies, but also applied across the entire German machine tool industry.
This work led to the development of a classification and coding system for the manufacturing environment (The Opitz System). Within this system, parts which were manufactured in the same way were grouped together.

It should be noted that parts which shared common manufacturing approaches did not necessarily have the same design characteristics. Similar parts from a manufacturing point of view are often different than similar parts from a design point of view. (See Figure 2.)

The application of classification and coding established that large numbers of similar parts were being made over and over again by manufacturing organizations. If large numbers of similar parts were being manufactured almost continuously, then why not dedicate groups of machine tools to manufacture these parts? With such a scheme, common jigs, fixtures, and tools could be used. Set-up times would obviously be reduced, as would throughput times. This led to the development of Group Technology workcells. The machine tools in each workcell thus formed were often placed together. Machinists and foremen jointly shared the responsibility for making parts. (See Figure 3.) The early workcells resulted in a "poor man's mass production" - they created great improvements in productivity, and lowered throughput time, set-up time, and work-in-process costs.

The technique was applied in several plants in Europe and the United States with limited success. The problem was that it was primarily effective in relatively simple operations which did not have complex product mixes.

Many implementations were not successful. This was due to the fact that there were no analytical tools available to properly analyze the parts database for production flows, and to simulate load balances. A workcell might use one lathe 120% of the time, an adjacent milling machine only 10% of the time, and a grinder only 15% of the time. Balancing each workcell production load was an obvious problem.

In addition, there was great resistance to change on the part of managers. Managers did not like to rearrange tools, and wait one to two years for productivity increases to become apparent.

Thus, the workcell idea was restricted for the most part to plants with simple products.

Application to Design and Manufacturing

Through the 1950's and 1960's, there were coding and classification systems for design and coding and classification systems for manufacturing. They were primarily manual systems, using a relatively few number of digits or alphanumeric codes. None combined design and manufacturing applications.

Work at the Organization for Applied Scientific Research in The Netherlands (TNO) was carried out in the 1960's and 1970's to develop a classification and coding system which would serve both design and manufacturing needs, This work led to the development of the MICLASS system which included both design and manufacturing oriented sections. To meet both types of requirements, however, a code length of as many as 30 digits was required. In the manual system environment which existed at that time, the 30 digit code length could have been a problem.

TNO's response was to develop a computerized system which handled the classification and coding process in an interactive mode. This was quite a new approach at the time. Computers in the manufacturing environment were mostly used in batch modes up until then.

MICLASS

With the MICLASS System, the computer would ask a number of questions about the part being coded. These questions would relate to both design and manufacturing attributes. The computer might ask, for example, if the piece were round. If the answer were yes, it might continue by asking if it had deviations. It would then continue until it had enough information to create the code number. The user was required to respond only with “yes”, “no”, or with dimensions. The code number was set up essentially as a chain in which individual part attributes were represented by code number digits, thus “chaining” the part attributes together. (See Figure 4.)

When the code number was created, the computer would search its files to determine whether a part with the same or similar attributes had been designed or manufactured in the past. The code number thus became much more than a notation on a drawing: it was now the key to a database; a tool to recall what had been done in the past.

MICLASS also departed from previous systems by providing a universal code. A MICLASS code number could be as much as thirty digits long. The first twelve digits, which related to shape, form, dimensions, tolerances, and materials, were kept standard for all users.

There was initial resistance to this concept. It disturbed manufacturing people who were convinced that their parts were different from all others, and thus required a specific coding system. The fact remained, however, that all of these manufacturers were using the same standard machine tools to produce these highly similar parts, and the differences were not profound. Furthermore, the availability of eighteen additional digits meant that each user's MICLASS System could be customized to meet specific needs. It was thus possible within a corporation, for example, to have a basic twelve digit code which would serve the entire corporation, while each division had additional digits of its own to reflect specific needs. MICLASS thus provided both customized coding and classification, and *a* universal key to the database.

The MICLASS coding structure was based on TNO's analysis of many thousands of parts. From this analysis, family concepts had been developed. Thus, the vendor/consultant no longer asked the user how to structure the families; the structure was provided. If there were too many parts in a given class, it was a strong sign of unneccesary duplication.

Within this concept, MICLASS provided a tool for standardization.

If a user found that there were a number of allegedly different parts or process plans with the same code number, there had to be duplication. For example, a machine tool builder was found to have 521 similar gears. The files revealed 477 different process plans to produce these gears. When MICLASS coding focused attention on this situation, it was possible to reduce the 477 process plans to 71 standard "best" plans, thereby greatly simplifying production.

The MICLASS Matrix

The MICLASS System included a thirty position code. Values ranging from zero to nine could be assigned to each position. Therefore, MICLASS incorporated a 30 x 10 matrix - 300 places. When parts were being coded, they fell through this 300 hole "sieve". (See Figure 5 .) The proper definition of the eighteen "non-universal" digits in the MICLASS code became critical to the success of its application in any given organization.

OIR - The Organization for Industrial Research, Inc. - implemented MICLASS in many American companies in the late 1970's. Through these implementations, OIR developed a great deal of experience in the assignment of these digits in ways which were most beneficial to the user.

Both hardware and software technology moved rapidly in the late 1970's. Computers became smaller, cheaper, more powerful, and more frequently used as an interactive tool. The number of computers in manufacturing organizations grew significantly. Interactive coding and classification thus became very attractive. It provided the key to an interactive, intelligent interface between the users -- design and manufacturing engineers -- and the parts database.

Problems of Integration

As the use of computers in manufacturing grew, and as computer-aided design and computer-aided manufacturing became more widely accepted, new types of problems began to emerge.

It as not unusual for the design office to use a computer, and the manufacturing office to use another computer. Even if they were using the same machine, they often worked from different databases. At the same time, there might be a corporate database with information of use to both design and manufacturing, if it could be retrieved. There were growing pressures for the true integration of CAD and CAM.

The problem appeared to be in the quantities of data involved. A company might have hundreds of thousands, or even millions of parts. The integration of all the data for all parts would appear to be a monumental problem.

The key to the solution of this problem was the fact that things were not as they appeared to be.

In its work for many different companies, OIR had found that the number of truly different designs in any manufacturing environment range from approximately 2,000 to 6,000. Even companies with 500,000 parts or more prove to have no more than 6,000 really different designs or process plans. Thus, if the database could be sifted to find the few thousand really different parts, the problem would be much reduced.

As described previously, the early applications of classification and coding were in the design area, for design retrieval purposes. With the development of MICLASS, the applications were extended into manufacturing. Through the use of Group Technology analyses, design and manufacturing databases could be reduced to manageable size, The key tool in such an effort was OIR's MIGROUP family of programs which made it possible to thoroughly analyze and act on databases of part information in three basic areas: code number analysis; production flow analysis; and machine load analysis. Coding and classification became the 'sieve' to reduce the database size, and Group Technology was the tool for design and manufacturing analysis.

Computer Assisted Process Planning

In the 1970's CAM-I (Computer Assisted Manufacturing-International) looked at the feasibility of computer assisted process planning. At the time, computers were being used in process planning, but not at all effectively. In some companies, process plans were written out by hand, then sent to a key-punch operation and read into the computer., The computer would then produce a printout of the process plan as it had been key punched. In other words, the computer was serving as a multi-million dollar printing press.

The issue was how to consistently find and retrieve best process plans. The use of a part number had limited value. The number says nothing about how the part is to be manufactured, and part numbers are easily lost, confused, or forgotten. It seemed obvious that a code number would be more useful.

In 1979, OIR introduced MIPLAN, the world's first commercially available production oriented computer assisted process planning system.

The First Generation

With the development of MIPLAN, the first generation of classification and coding/Group Technology tools was complete. The MICLASS classification and coding system captured both design and manufacturing information, MIGROUP provided a means of analyzing and integrating such data, and MIPLAN was a practical means of applying computerization to process planning. (See Figure 6.)

With these tools in place it became possible to realize benefits which had not been possible only a few years before.

For example, MIGROUP analysis solved the problem of creating effective workcells in complex manufacturing environments. By coding parts and then analyzing them with MIGROUP, it was possible to define part families, production flow (what parts to what tools), and through simulation, to achieve load balancing.

In addition, OIR's increasing experience made new insights possible. For example, OIR found that even though product models may change, frequencies within part mixes remain relatively constant from year to year -- the number of truly different parts changes very little. This made it possible to form groups of dedicated machine tools for particular part families to serve both short and long term needs. Furthermore, it became clear that, it was not necessary to physically group the dedicated machine tools together, only to assign them to part families.

With the application of MIPLAN, it became evident that computer assisted process planning was useful not only for retrieving process plans, but that it could also be used for cost reduction. A small shaft, for example, could be made on a small lathe, or a five axis milling machine, with obvious manufacturing cost differences.

It became apparent that process planning was a major determinant of the final cost of a product. Hence, the optimization of process planning would translate into optimal product costs. MIPLAN provided a tool to serve this purpose.

The database of code numbers, with their associated process plans, served as a "back door entry" into Group Technology analysis. As this database of manufacturing information, organized by code numbers, was built up, it would become possible to move in the direction of standardization using Group Technology, by analyzing the code numbers.

In other words, planners would begin by using the system as an "electronic pencil", and utilizing the time they saved in using the system, they could begin to standardize process plans, and define optimal manufacturing methods.

Pictorial Process Planning

In the 1970's, there was a tremendous growth in the acceptance of computer graphics systems.

We are in the age of visual communications. Spurred on by television, we are in a period when people are reading less and less and relying more on pictures and illustrations than ever before.

Process plans can be very lengthy documents to read - in some companies they normally run twenty pages or more. With people reading less and less, and with increasingly poor comprehension levels, the integration of computer assisted process planning and computer graphics presented an interesting opportunity.

OIR developed a pictorial process planning system (initially with Computervision) that merged the benefits of both these technologies.

With pictorial process planning, the user utilizes an alphanumeric terminal to compose the process plan, and a graphic terminal to illustrate the plan with machining details, tool set-ups, etc.. A formatter is used to join them, and hard copies with the process plan on one-half of the page and the accompanying illustrations on the other half of the page are now practical. The results are dramatically clear process plans. (See Figure 7.)

At the moment, the use of pictorial process planning is limited because of the capacity of existing graphic systems.

With the introduction of new 32 bit graphic systems, however, the alphanumerical and graphic terminals will be jointly used in the process planning environment, with more users on each system.

THE FUTURE -- THE TECHNOLOGY OF THE EIGHTIES

Classification and coding, Group Technology, and computer assisted process planning are now entering into a new phase in their evolution - a phase which reflects the advancement of hardware and software technology, the increasing sophistication of manufacturing people, and the rising economic pressures on manufacturing organizations.

MULTICLASS

The first of the new generation of classification and coding systems is MULTICLASS, developed entirely by OIR.

The development of MULTICLASS began with a detailed analysis of years of experience with the MICLASS System. The analysis revealed that the 30 x 10 matrix of the fixed MICLASS structure was not always the most efficient approach to classification and coding. In fact, each user tended to take advantage of only a portion of the matrix, depending on individual needs.

In fact, if the matrix was looked on as a 30 x 10 sieve through which the parts passed as they were classified, an individual company's use of the sieve might be graphically depicted as a potato shape. (See Figure 8). The shape of the potato varied with each company, but was similar for companies in the same type of industry.

In almost all cases, the size of the potato actually used was small. In other words, the typical user took advantage of only a small section of the matrix, and much of the use involved sections of the code which were specially tailored for the user company.

It should be noted that the issue is not just in the number of digits per se. The coding process is essentially a decision tree process. Coding with an entire tree when only a small branch is needed means that extra time, energy, and computer power is wasted.

At the same time, the success of classification and coding and computer assisted process planning for machine parts and sheet metal parts had encouraged manufacturers to seek to apply the same techniques to other types of components - machine tools, assemblies, electronics, etc..

The MULTICLASS concept responds to both these situations.

MULTICLASS is a comprehensive software system which can handle multiple coding structures. Instead of a fixed format, such as MICLASS, MULTICLASS is a very flexible tool which can be tailored to meet the user's specific requirements. MULTICLASS can be used vertically, for increasingly specific classification, and horizontally, to accommodate different types of components (machined parts, electronics, etc.). See Figure 9.

For example, a thirty-two digit code structure can be used in MULTICLASS to organize a total database into generalized families for sheet metal and/or machined parts. With the new MULTIGROUP analysis system, it is then possible to analyze these families and create individualized decision trees for them, thus creating a more finely tuned system which meets company needs extremely efficiently.

The process can be repeated to create an even more finely tuned system, using the decision tree "handlers" in the MULTICLASS System.

Ultimately, the very finely tuned decision trees can be used with the MULTIPLAN computer assisted process planning system in a quasi-generative process planning mode -- where very specific process plans can be retrieved because the system is so finely tuned to the products being manufactured.

Multiple Coding and Classification

The flexibility of the MULTICLASS System is demonstrated in its capability to handle almost any type of part or component used in manufacturing. In addition to machined and sheet metal parts, for example, MULTICLASS can be set-up for the coding and classification of electronics, purchased parts, assemblies and sub-assemblies, machine tools and other elements.

MULTICLASS uses span the range of applications which have evolved in recent years and which will continue to evolve through the eighties, from simple design retrieval, to design and manufacturing standardization, to generative process planning.

MULTICLASS provides a common link for many different elements of the design and manufacturing database. Thus it is possible, through MULTICLASS, to meet all coding and classification needs (i.e. database interfaces) with a single system.

Therefore, the MULTICLASS System thus provides a common link for many different elements of the design and manufacturing database.

MULTICLASS is normally provided to the user with at least two general coding structures already installed -- for machined parts and for sheet metal parts. OIR specialists can then work with the user to define the other decision trees (if any) which will be needed initially. In time, the user will add other structures to meet specific needs as they evolve. In practice, the user has the opportunity to analyze his needs using the general coding structures and then design the more specific decision tree structures. It is much like having a large funnel and then using smaller funnels to catch more specific attributes.

This is in contrast to the decision tree system developed at Brigham Young University. DClass, as it is called, is a very capable decision tree handling system. It is not marketed with any specific coding structures already set-up, or with any group technology analysis programs. Thus, the user has to "start from scratch" and do the most difficult work himself.

MULTIPLAN

The MULTIPLAN Computer Assisted Process Planning System also goes well beyond anything which was previously avalable.

MULTIPLAN has the MULTICLASS System embedded in it. This means that the user has a wide range of options in using it. Again, the options are both verticai and horizontal.

The vertical flexibility of MULTIPLAN means that it can be utilized as a generative process planning system as well as being used as a variant system. Because the MULTICLASS structure makes it possible to code with increasing sensitivity to any type of specific attributes, it is possible to begin with a general structure for variant planning and then, with use, to become increasingly specific.

MULTIPLAN can thus be used progressively -- from an "electronic pencil," to a variant system, to generative process planning. The advantage for the user is that the return on investment begins almost immediately

MULTIPLAN has also been designed for horizontal use. In many manufacturing operations today, the components involved in production are not limited to machined parts or sheet metal. There may be electronic components, electro-mechanical devices, assemblies and sub-assemblies, purchased parts and more. The MULTIPLAN System will accommodate whatever components are manufactured or assembled. Again, a major advantage is that all of this is done within a single system.

MULTIGROUP

The MULTIGROUP System represents a quantum jump in Group Technology. Its development also resulted from a detailed analysis of years of experience in actual Group Technology applications.

It thus reflects both the experience of the past decade and the technology of the next. Whereas past Group Technology systems, including MIGROUP, were somewhat cumbersome and required a great deal of technical knowledge to operate successfully, MULTIGROUP is a menu-driven, clearly articulated system that can be introduced and applied much more quickly and efficiently than systems of the past generation.

MULTIGROUP can be used to analyze product mix, workload, and work center activities, in addition to its application to the formation and analysis of part clusters for such things as part family definition and generative process planning.

In brief, MULTIGROUP is a very modern tool for design and manufacturing standardization, the development of optimal routings, purchasing decisions and much more. In many ways, it is the realization of the initial promise of Group Technology "to bring the economies of mass production to batch manufacturing."

MULTIGROUP is the first Group Technology system to incorporate a flexible database approach. Like MULTICLASS and MULTIPLAN, its applications can extend far beyond machined and sheet metal parts -- to electronics, assemblies, and all of the other types of components used in contemporary manufacturing environments. It can work with different numeric codes or designators, and with the full range of MULTICLASS decision trees. It can thus be used to analyze the production of a very large plant or company, or to balance the load in a very small workcell.

MULTIGROUP greatly expands the practical applications of Group Technology and, in many ways, is the realization of the potential which Group Technology exponents predicted.

Transition From MICLASS

One of the problems associated with the introduction of new software systems has been incompatibility. A new system is developed and the old system must be completely abandoned. This is not the case with the transition from MICLASS to MULTICLASS.

The MULTICLASS System can contain a MICLASS module which may be accessed directly, and it is possible to use MICLASS as the first step in the development of highly specific machined and sheet metal part MULTICLASS codes. It is also possible to re-code MICLASS coded parts into MULTICLASS.

It should be noted, however, that the much broader 'scope and greater depth of the MULTICLASS System would make it advisable for new Group Technology users to begin with MULTICLASS. There is no reason to include MICLASS in a new system.

Generative Process Planning

"Generative" process planning has been a subject of increasing discussion in recent years. In a generative process planning system, process plans are generated automatically -- that is, the user enters a description of the part, and the system automatically generates the correct process plan to produce it. The term "generative" is usually used in contrast to "variant." In a variant system, the user enters a description or identification of the part and the system produces a process plan which may require editing or assembly before it can go out on the shop floor.

There are essentially two approaches to generative process planning. The first incorporates theories of artificial intelligence. In such a system, the geometry of the part is recognized and the system generates the plan based on its understanding of the manufacturing methods needed to produce such a geometry.

In the other approach, Group Technology is the key. Here, the process plan is based on the prior determination, through Group Technology analysis and classification and coding, of the "best manufacturing" methods for the part at that production facility. Past experience, available machine tools, families of parts, and other considerations come into play.

The major advantage of the Group Technology approach is that it can be built up over time, while the user is deriving benefits from the process planning system. With the MULTIPLAN computer assisted process planning system, for example, the user can begin by utilizing the system as an "electronic pencil" to significantly reduce process planning time. As the system is used, a database is being built for standardization of design and manufacturing, selection of optimal manufacturing routings, definition of highly similar parts, and other factors required for the implementation of generative process planning.

The resulting system is thus much more finely tuned to the user's needs and has produced a return on investment prior to the full-scale implementation. It has also been tested in use as it is being developed.

The OIR approach is thus directed to Group Technology.

The Future

Classification and Coding, Group Technology, and Computer Assisted Process Planning have progressed rapidly in the past few years, evolving from novelties to widely used working tools. In the process, many production economies have been achieved, and the productivity of the people involved has increased measurably as the need for human intervention for repetitive work has become minimized.

Although hardware and software technology has improved tremendously in recent years, Computer Aided Design and Computer Aided Manufacturing are still in their infancies in many ways.

In the future, computers will begin to really understand what is in their databases, using solid modeling technology. Decision trees embedded into computer graphics systems will generate process plans virtually automatically, by truly recognizing parts and other components. It may be at that time that code numbers are no longer needed, since retrieval and analysis will be direct and automatic. The new OIR systems provide a base for such technology.

The disappearance of code numbers would mean the end of human involvement in such things as the preparation of process plans. While this may become technically feasible, there are serious questions as to whether it would be desirable.

The computer is a very useful tool and it should be used to maximum advantage. On the other hand, manufacturing is -- and will be -- both an art and a science. Human judgement is an essential element of the manufacturing process. As systems evolve, there will still be a need for judgements by design and manufacturing engineers, process planners, and others.

Without such judgement, we could make a goat when we are looking to produce a camel.

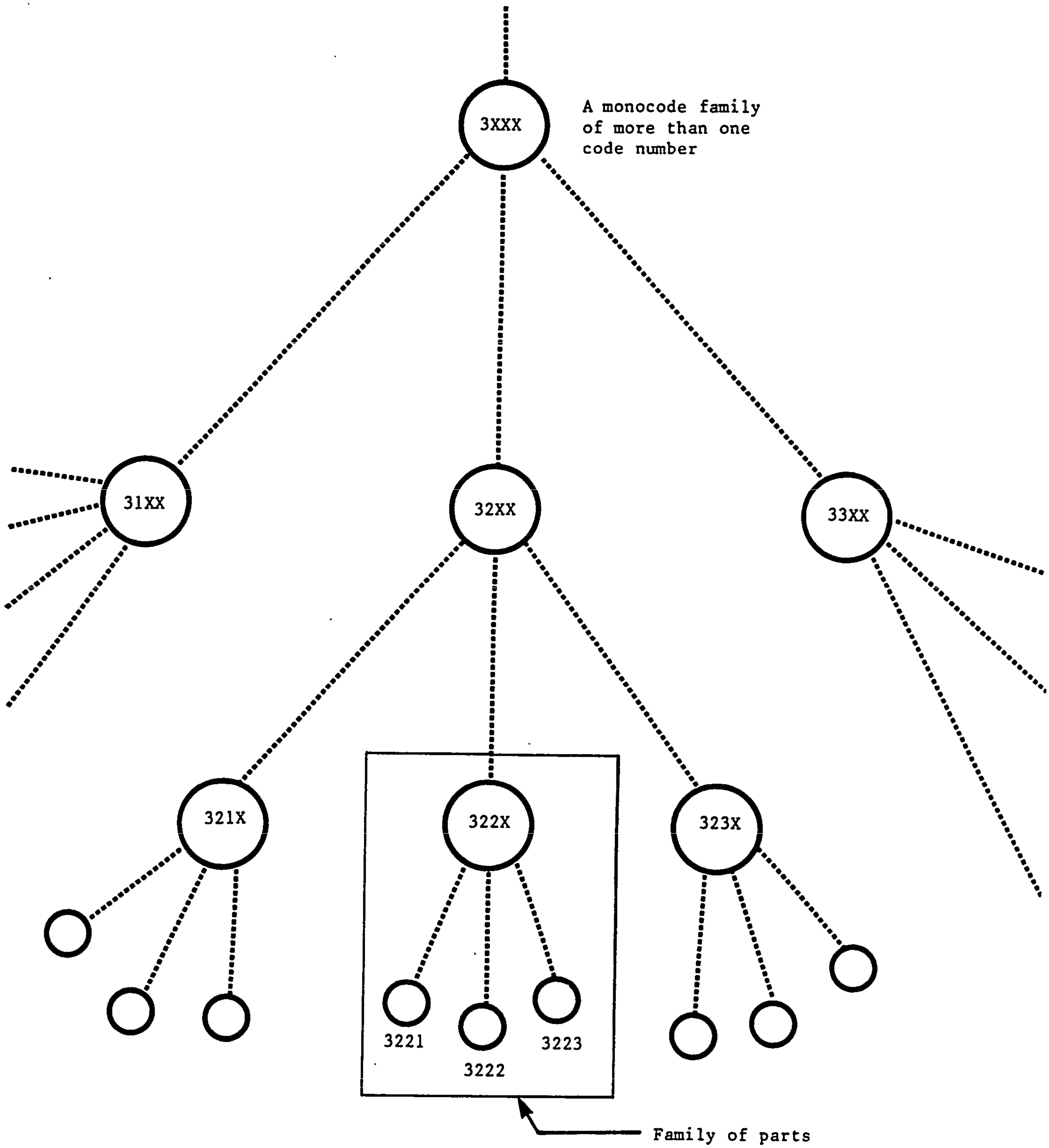


FIGURE 1

The Structure of a
Classification and Coding System
Based on Hierarchical Principles

Similar Parts Based on Manufacturing Process

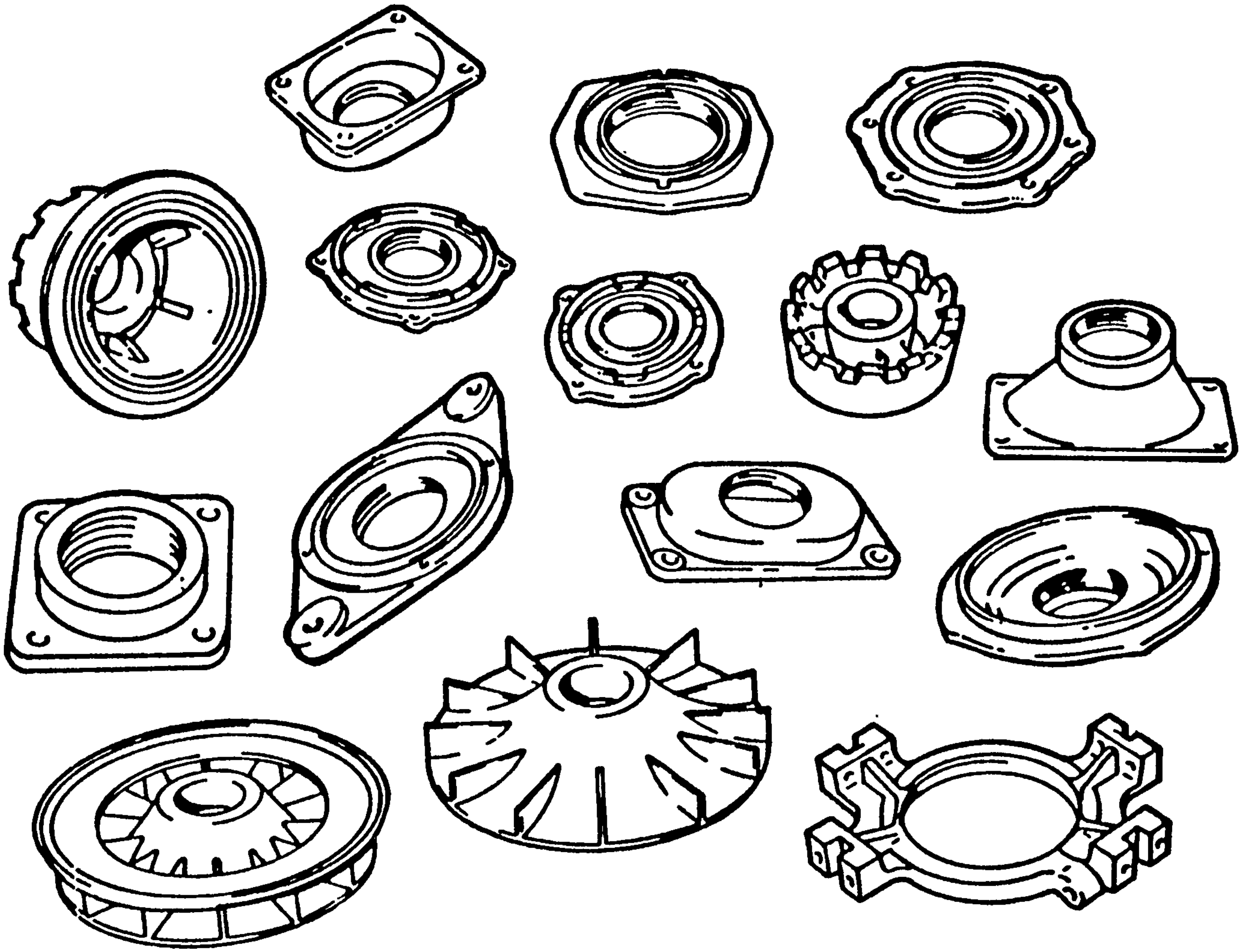


FIGURE 2A

Similar Parts Based on Shape

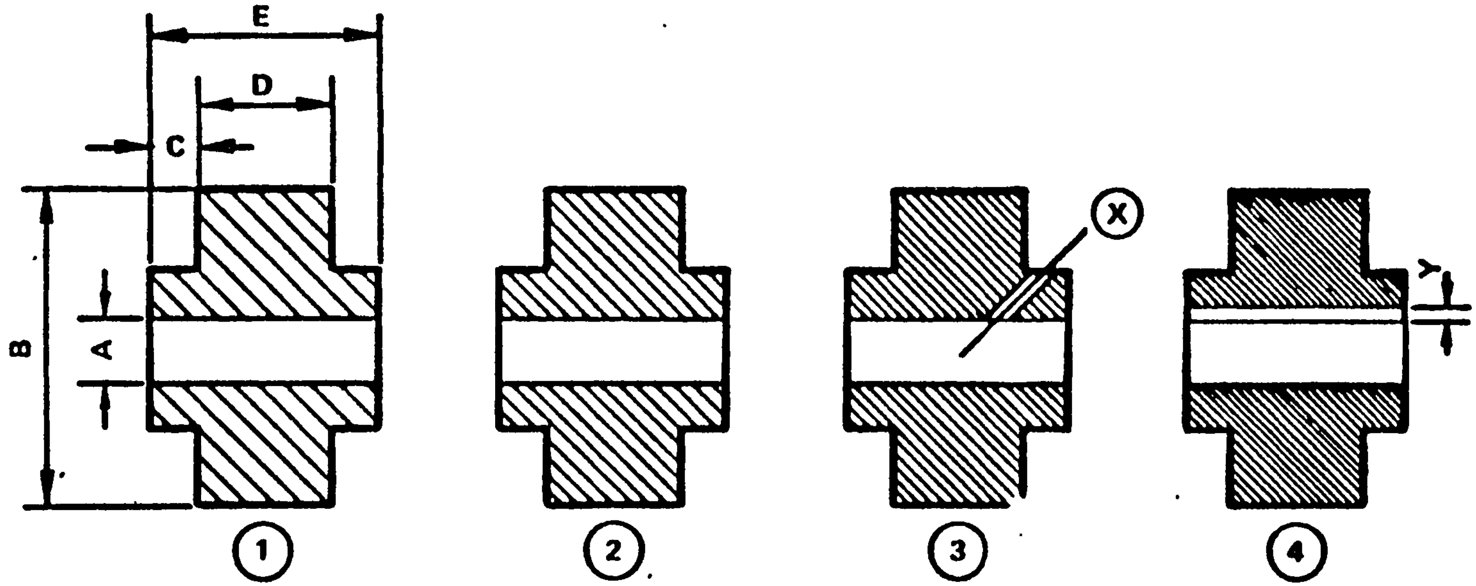
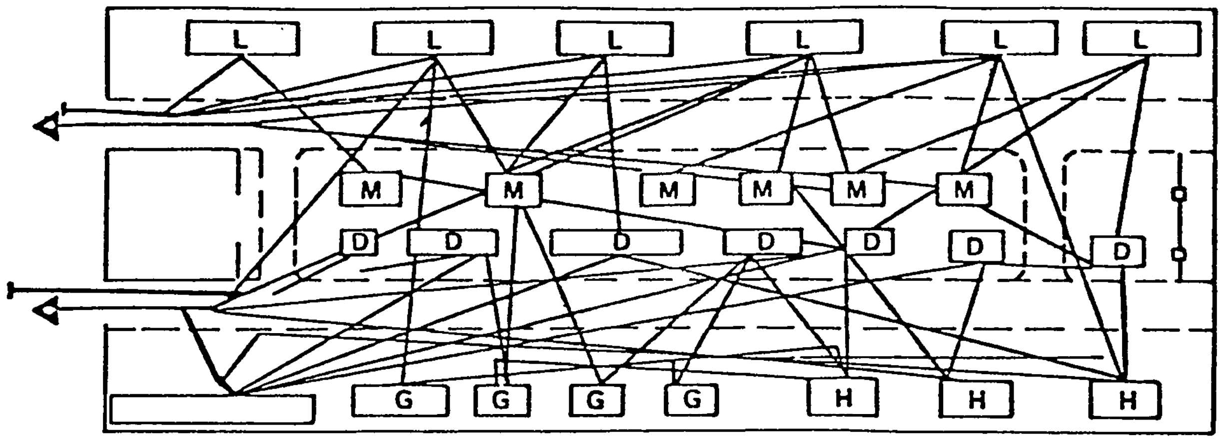


FIGURE 2B

A. COMPLICATED MATERIAL FLOW SYSTEM (Functional Layout)



B. SIMPLE MATERIAL FLOW SYSTEM (Work Cell Layout)

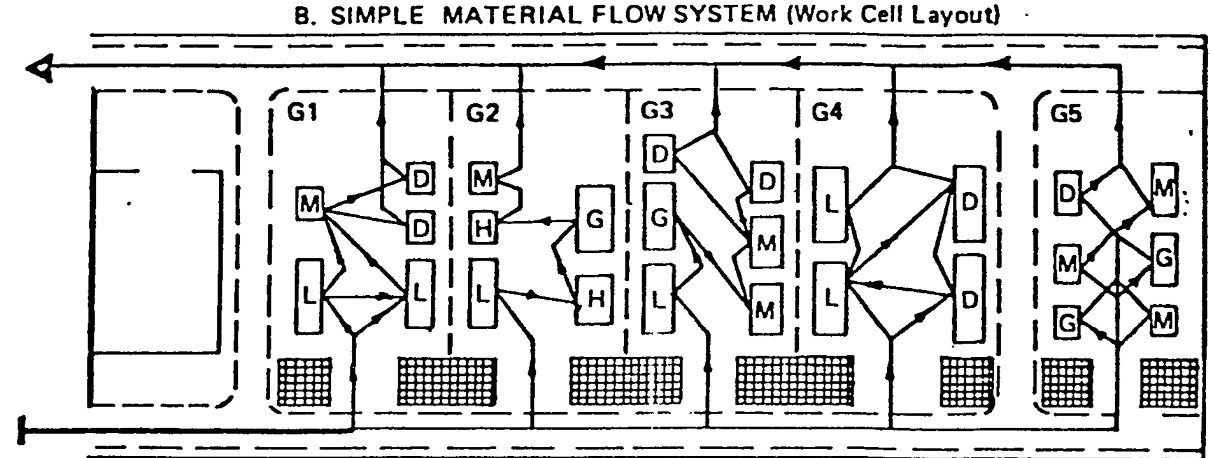


FIGURE 3

Simplification of Material Flow
With Work Cell Layout

POLYCODE STRUCTURE

DIGIT	CLASS OF FEATURE	POSSIBLE VALUES OF DIGITS							
		1	2	3	4	5	6	7	8
1	EXT. SHAPE	$SHAPE_1$	$SHAPE_2$	$SHAPE_3$	–	–	–	–	–
2	INT. SHAPE	NONE	$SHAPE_1$	–	–	–	–	–	
3	# HOLES	0	1 – 2	3 – 5	5 – 8				
4	TYPE HOLES	AXIAL	CROSS	AXIAL & CROSS					
5	FLATS	EXT.	INT.	BOTH					
6	GEAR TEETH	SPUR	HELICAL						
7	SPLINES								

FIGURE 4

A Classification and Coding System Based on Polycode Structure

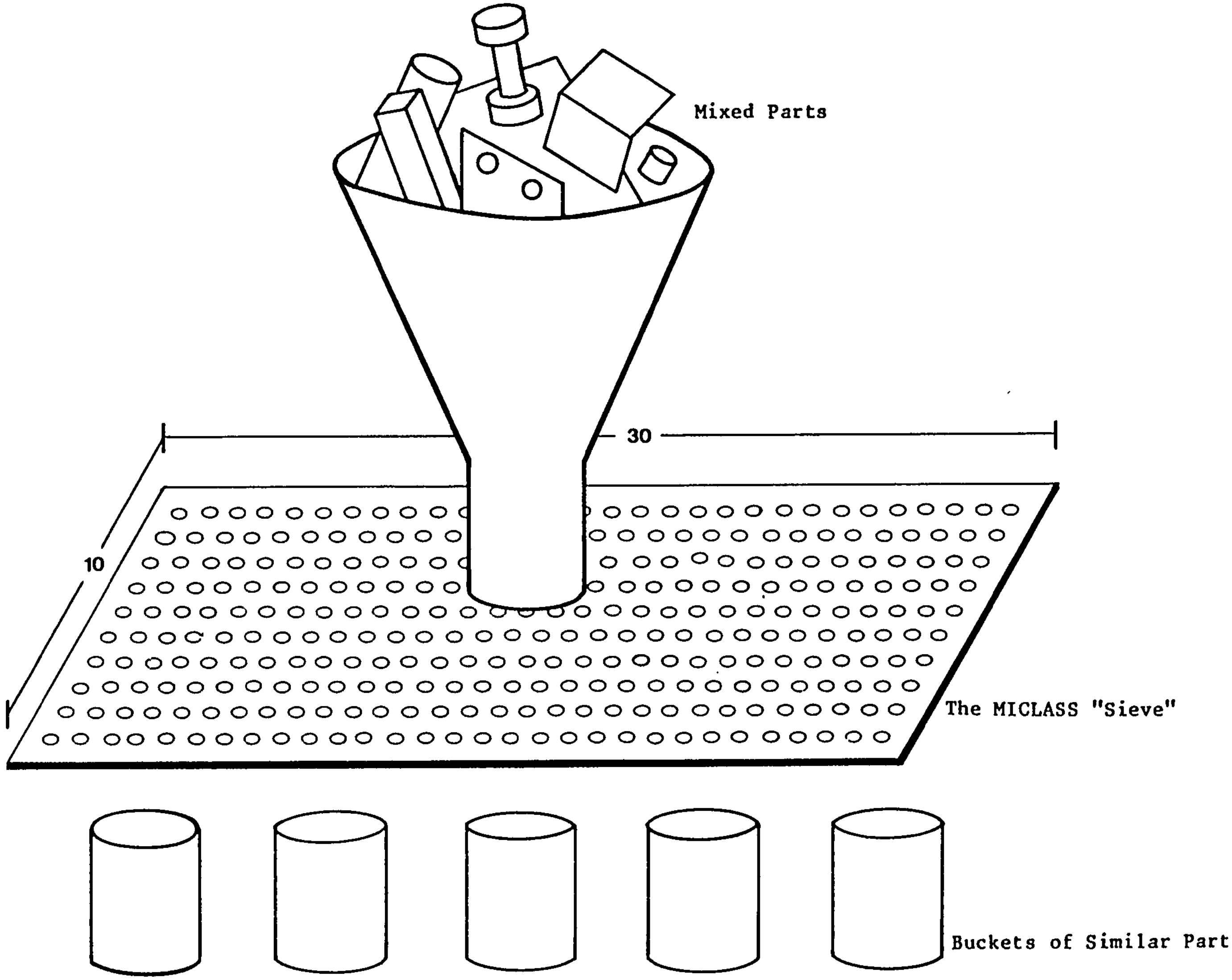


FIGURE 5

A Classification and coding system can be compared to a sieve which sorts parts by specific attributes. The MICLASS System works like a sieve with 300 holes.

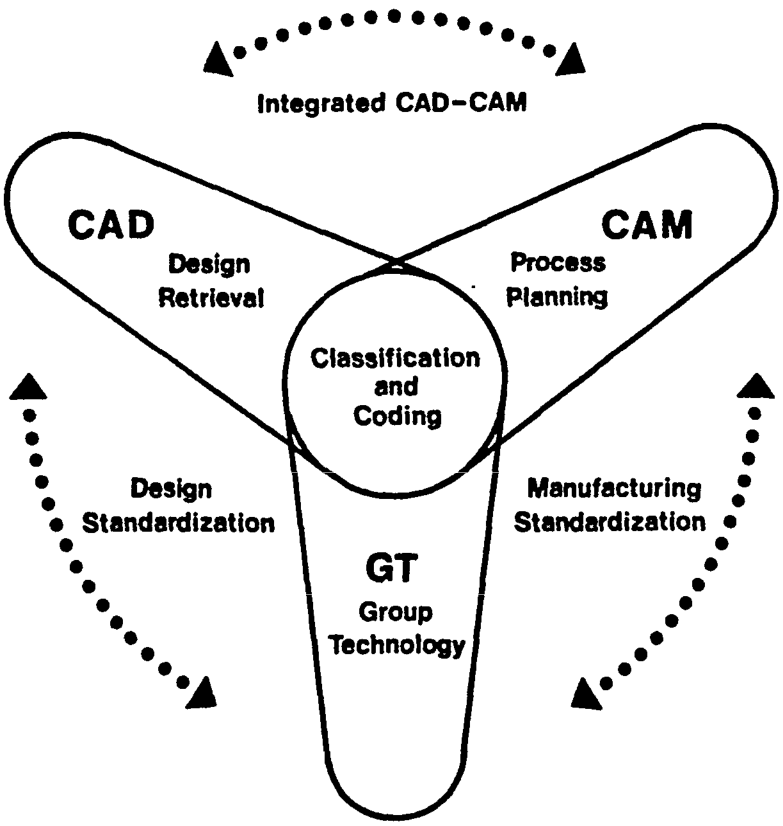


FIGURE 6

Classification and coding is the key to an integrated approach to CAD and CAM

PART NO: 190105 PART NAME: FRONT PLATE FORMAT: NCS.1

PLNG REV: 1 DWG REV: A PLANNER: ADAMS

CODE • 8798-3711-1189-3433-1400-0000-0000-00

0040	5002 MACHINE PER TAPE •1
	SET UP IN FIXTURE •1
	WITH STD ANGLE PLATE
	•A123 PER SKETCH
	ROUGH & FINISH FACE
	- HOLD .25+-.02 DIM.
	USE 4" DIA FACE MILL
	C-DRILL (3) HOLES
	DRILL (1) HOLE 3/8 DIA.
	DRILL (2) TOOLING HOLES
	5/16 DIA.
	DRILL (2) TOOLING HOLES
	.365/.370 DIA
	AND REAM TO .376/.370 DIA.
	SET UP = 2.50
	PIECE TIME=.350

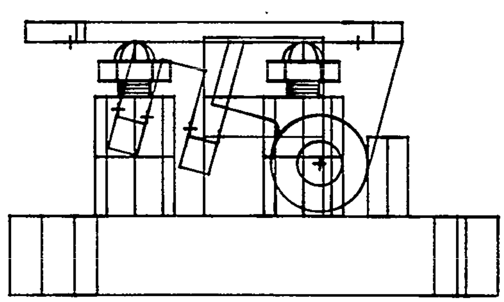


FIGURE 7

Pictorial Process Planning is the Integration of Computer Assisted Process Planning and Computer Graphics Shown above is a sample print out.

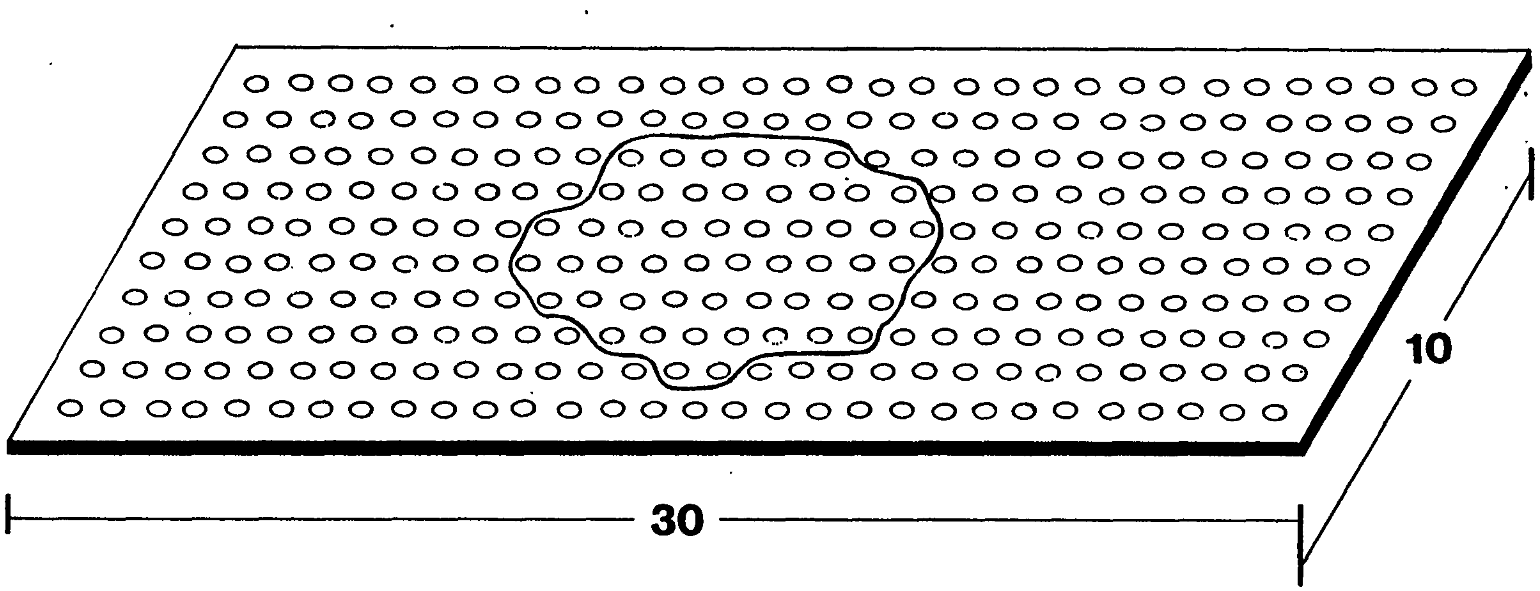


FIGURE 8

A fixed classification and coding system is not always the most efficient. The "potato shape" represents the relatively small portion of the MICLASS matrix typically utilized by a company.

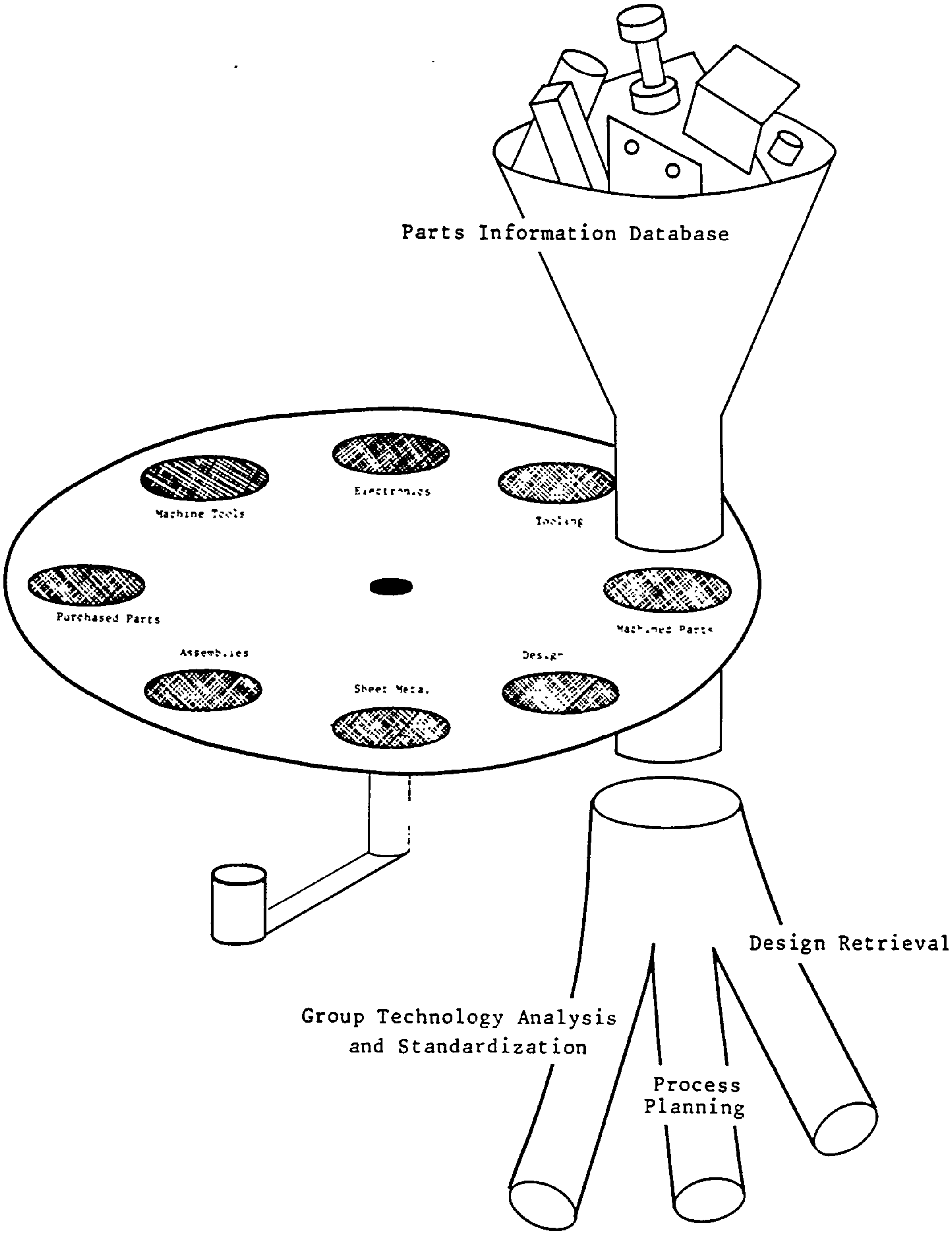


FIGURE 9

*In contrast to the "fixed sieve" metaphore for MICLASS,
MULTICLASS can be likened to a machine
that offers a wide selection of different sieves.
That is, MULTICLASS is a very flexible tool
which can handle multiple coding structures
and can be easily tailored to
meet a user's requirements.*

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